Chip Integrated, Hybrid EHD/Capillary Driven Thermal Management System Project

Completed Technology Project (2010 - 2015)

Project Introduction

Chip-Integrated, Hybrid EHD/Capillary-Driven Thermal Management System is a two year that will leverage independently attained yet related prototype hardware advances for electronics thermal management into a ground breaking hybrid thermal control system for spacecraft applications.

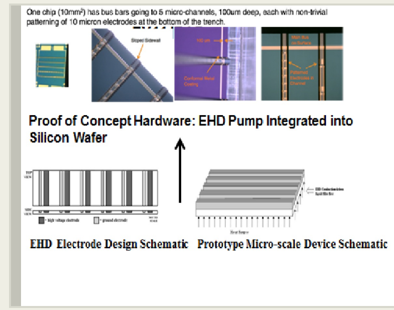
Objectives

- Design, fabricate, and validate the chip integrated hybrid EHD/capillary device
- Quantify the reduction in required radiator area by utilizing chip integrated thermal management system (TMS)
- Fabricate and validate in thermal vacuum environment the Chip Integrated Hybrid EHD/Capillary TMS

The proposed research will develop novel enabling thermal management technology addressing subsystem (on-board processing and electronics thermal management) as well as spacecraft level design. The proposed validated prototype system would achieve the following engineering advantages:

- EHD/capillary-driven thermal management system with low mass/volume and power consumption which limits the total power dissipation required of the thermal subsystem;
- high heat transfer coefficient mechanism using thin film evaporation to maximize the heat rejection temperature and reduce the required radiator area;
- self-regulating and smart fluid management to permit heat rejection from an arbitrary surface to the lowest available temperature sink.

The current state of the art for electronics thermal control, wherein thermal control hardware is remotely integrated and requires relatively massive, voluminous and power consuming resources as well as large temperature differences to serve as the driving potential transferring dissipated heat. These characteristics impede the goal of capable, efficient, and miniaturized on-board processing systems. Furthermore, processing capability is limited by thermal control considerations, such as the amount of heat rejected, the heat flux along the path of heat rejection, and the temperature difference between the electronics components and the thermal sink. Thus, technologists seek to integrate the thermal management solution directly into the chip layout, substrate structure, and/or package design. This will substantially boost the cooling performance, while introducing significant reduction in the package size, and requiring much smaller overall system temperature driving potential: a 3-D integrated solution that is lighter, more compact, and capable of greater heat transport. In addition, a two-phase device would provide thermal uniformity, reducing thermal stresses and thus enhancing overall component reliability. Functionally, this concept will reduce the thermal resistance



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between the chip and the radiator, raising the heat rejection temperature with little cost in power consumption. The net effect is to increase the available temperature for heat rejection, presenting the spacecraft with the advantages of increased power levels and/or reduced radiator mass and volume. The prototype TMS hardware will consist of an integrated heat sink chip embedded hybrid EHD/capillary-driven fluid management device that would ensure liquid supply and system self- regulation at the evaporative surfaces.

Anticipated Benefits

Cross-cutting technology enables spacecraft system and subsystem miniaturization through tight thermal control. Embedded thermal control subsystems can improve electronics component reliability by reducing mechanical stresses and related hardware failure. The target technology application is CubeSat Missions; however, any technology advances are likely to be applicable to virtually any spacecraft mission.

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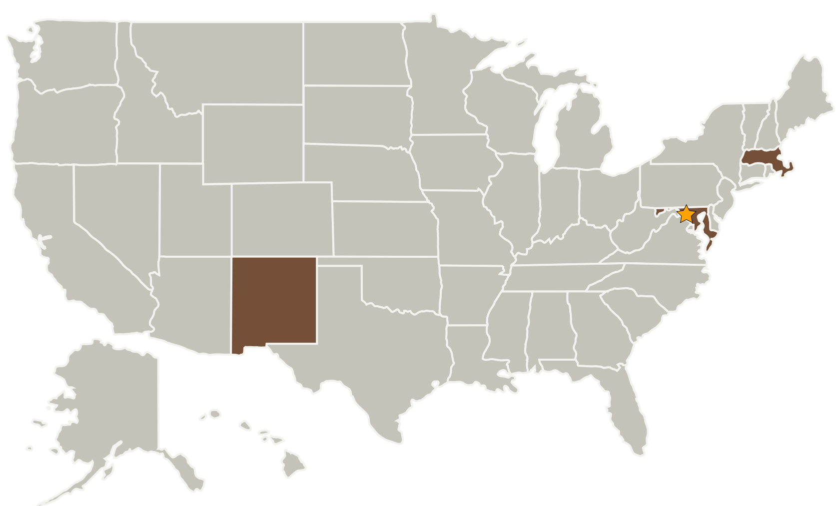
Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Mission Support Directorate (MSD)

Lead Center / Facility:

Goddard Space Flight Center (GSFC)

Responsible Program:

Center Independent Research & Development: GSFC IRAD

Project Management

Program Manager:

Peter M Hughes

Project Manager:

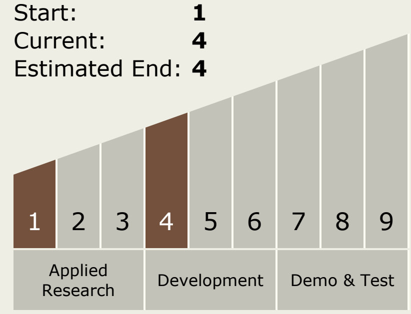
Theodore D Swanson

Principal Investigator:

Jeffrey R Didion

Technology Maturity (TRL)

Start: **1**
Current: **4**
Estimated End: **4**



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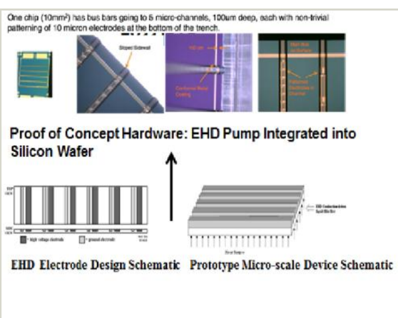
Organizations Performing Work	Role	Type	Location
★Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland
University of Maryland-College Park(UMCP)	Supporting Organization	Academia	College Park, Maryland
Worcester Polytechnic Institute	Supporting Organization	Academia	Worcester, Massachusetts

Primary U.S. Work Locations	
Maryland	Massachusetts
New Mexico	

Images



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Chip Integrated, Hybrid EHD/Capillary Driven Thermal Management System Project
(https://techport.nasa.gov/image/3012)

Technology Areas

Primary:

- TX14 Thermal Management Systems
  └ TX14.2 Thermal Control Components and Systems
    └ TX14.2.3 Heat Rejection and Storage

Project Website:

http://aetd.gsfc.nasa.gov/